TYPE Editorial
PUBLISHED 30 June 2025
DOI 10.3389/feart.2025.1636075

Check for updates

OPEN ACCESS

EDITED AND REVIEWED BY
Wouter Buytaert,
Imperial College London, United Kingdom

*CORRESPONDENCE
Marcel Liedermann,
marcel.liedermann@boku.ac.at

RECEIVED 27 May 2025
ACCEPTED 18 June 2025
PUBLISHED 30 June 2025

CITATION
Liedermann M, González-Fernández D, Mendrik F, Biermann L and van Emmerik THM (2025) Editorial: Contributions to river plastic monitoring across scales, volume II. *Front. Earth Sci.* 13:1636075. doi: 10.3389/feart.2025.1636075

Editorial: Contributions to river plastic monitoring across scales, volume II

Marcel Liedermann[1]*, Daniel González-Fernández[2], Freija Mendrik[3], Lauren Biermann[4] and Tim H. M. van Emmerik[5]

[1]Department of Landscape, Water and Infrastructure, Institute of Hydraulic Engineering and River Research, BOKU University, Vienna, Austria, [2]Department of Biology, University Marine Research Institute INMAR, University of Cádiz and European University of the Seas SEA-EU, Puerto Real, Spain, [3]International Marine Litter Research Unit, School of Biological and Marine Sciences, University of Plymouth, Plymouth, United Kingdom, [4]Plymouth Marine Laboratory, Plymouth, United Kingdom, [5]Hydrology and Environmental Hydraulics Group, Wageningen University, Wageningen, Netherlands

KEYWORDS

plastic pollution, macroplastic, microplastic, monitoring, oceans, rivers

Editorial on the Research Topic
Contributions to river plastic monitoring across scales, volume II

Introduction

Plastic pollution in aquatic environments has emerged as a critical global issue, with rivers playing a significant role in transporting plastic debris from land to sea. The complexity of riverine plastic transport is influenced by various factors, including the physical properties of plastics such as type, size, shape, and density, which affect their spatiotemporal distribution in flowing waters (Range et al., 2023). Rivers, however, not only act as conduits for plastic debris but also serve as temporary or perpetual sinks, particularly in tidal zones or compounded stretches, also contributing to the formation of localized accumulation zones (van Emmerik et al., 2022; Liro et al., 2022). These riverine plastic hotspots, while smaller in scale compared to oceanic counterparts, exhibit significantly higher concentrations of plastic, posing risks to ecosystem functioning and human health (e.g., Liro et al., 2022; Tasseron et al., 2024).

Monitoring and quantifying plastic transport in rivers is essential for understanding the dynamics of plastic emissions and validating global estimates (Vriend et al., 2020). Despite advancements in detection technologies, such as deep learning and acoustic methods, challenges remain in achieving continuous and accurate monitoring data and in method harmonization (van Emmerik et al., 2023). New techniques like using the Acoustic Doppler Current Profiler (ADCP) for macroplastic detection (Boon et al.) and instance segmentation models using deep learning architectures like YOLOv8 (e.g., Ahmed et al., 2023; Fan et al., 2024; Kataoka et al.) are being developed to enhance detection capabilities and provide more reliable data. An important step was made towards harmonization of data evaluation and determination of plastic transport (Pessenlehner et al.). These innovations are important in order to create simplified application possibilities and thus improve global datasets and their interpretation. The urgency of addressing plastic pollution is underscored by its detrimental impacts on ecosystems and human health, necessitating comprehensive research and effective policy measures. Plastic debris can lead to ingestion, entanglement, and suffocation of marine life, and its presence in the food chain poses severe health risks to humans, including exposure to toxic chemicals (e.g., Issac and Kandasubramanian, 2021). Global efforts, including the UN's push for a legally binding treaty (March et al., 2024; UNEP, 2024) and the EU's ban on single-use plastics, highlight the need for coordinated action to mitigate these impacts (European Commission, 2022; IISD, 2022).

Contributions to river plastic monitoring across scales

This Research Topic aims to highlight recent studies that explore innovative methodologies and provide insights into the mechanisms of plastic transport and accumulation in riverine environments. Methodological Improvements to quantify plastic fluxes and stocks are presented that advance the scientific field, while studies on the origin and fate of plastic help to develop the most sustainable avoidance strategies. The general discussion brings a sharpened focus on future research topics. By advancing our understanding of these processes, we can better support policy decisions and develop strategies to reduce plastic pollution, ultimately contributing to the preservation of aquatic ecosystems and the health of communities worldwide.

Methodological Improvements to quantify plastic pollution

In the study of Boon et al., authors propose a novel use of ADCP technology, typically used for flow velocity and sediment measurements, to detect macroplastic items suspended in rivers. Through controlled, semi-controlled, and field experiments, the researchers demonstrated that ADCPs can identify plastic items even amid natural scatterers like organic material, aquatic life, and air bubbles. Although distinguishing plastic characteristics (size, material, orientation) remains a challenge, the study suggests that item-specific echo signatures could enhance detection accuracy. The method, when calibrated with net-sampling data, shows potential for continuous, long-term plastic monitoring through existing, standard ADCP measurements. This could offer new insights into plastic transport trends and the effectiveness of mitigation strategies.

Kataoka et al. focus on detecting floating macroplastic debris (FMPD) using advanced computer vision. They developed five instance segmentation models based on the YOLOv8 architecture, trained on over 7,000 images from seven rivers. The models achieved strong performance in both object detection and image segmentation tasks. Crucially, the study found that ground sampling distance (GSD) significantly impacts detection accuracy as smaller GSDs enhance segmentation, while larger ones aid object detection. Additionally, careful category selection reduced false positives. These insights are key for standardizing international FMPD monitoring protocols and improving models to estimate plastic transport, enhancing our understanding of land-to-sea plastic emissions.

Pessenlehner et al. offer an in-depth exploration of riverine plastic transport dynamics within the Austrian Danube River, focusing on the critical role of spatiotemporal and discharge-dependent assessments for precise plastic flux determination. By employing a net-based cross-sectional multi-point approach and comparing an impounded section near Aschach with a free-flowing stretch near Hainburg, the study uncovered significant vertical and lateral variability in plastic concentrations. This underscores the importance of multi-point sampling for accurate assessments. The research adapts suspended sediment-monitoring methodologies and introduces a quantification approach, independent of the underlying sampling technique. Furthermore, the study calls for improved sampling techniques, especially for capturing small microplastics and more seldomly transported large microplastic items. The findings stress the role of hydro-morphological conditions in plastic distribution and advocate for basin-wide, seasonally aware monitoring to better support mitigation policies.

Analyses of the origin and fate of the plastic

In London, Ontario, researchers examined macroplastic and large microplastic accumulation in stormwater systems using LittaTrap™ devices. The study, authored by Kozikowski and Corcoran, identified pedestrian traffic as a key contributor to debris levels, with areas like parks and community centers showing the highest counts. Seasonal variation was also significant, with summer having the highest plastic loads due to increased outdoor activity. Finer mesh traps proved effective at capturing microplastics, suggesting enhancements to urban stormwater systems. Interestingly, no strong correlation was found between plastic levels and environmental factors like wind or precipitation, highlighting the complex interplay of urban behaviors and environmental conditions. The study supports the need for broader geographic coverage and sustained monitoring.

Talavera et al. investigated macroplastic pollution in the Tullahan River, a heavily polluted urban waterway in Metro Manila, Philippines. Through visual surveys and manual Research Topic, the researchers found that food wrappers and thin polyethylene plastics dominated both floating and riverbank litter. Human activity, especially packaging habits and inadequate waste management, was identified as a primary driver of pollution. The study also noted that residential and industrial land use areas contributed most plastic waste. These findings call for stronger plastic regulation and waste management improvements Additionally the field data collected can enhance modeling accuracy and policy development. The research provides a foundation for targeted interventions in urban rivers heavily burdened by plastic waste.

A study from the Sierra Gorda Biosphere Reserve (SGBR) in Mexico revealed the presence of microplastic pollution in protected freshwater ecosystems. Granados-Sánchez et al., collected samples from rivers and reservoirs, finding significant microplastic concentrations in both water and sediments. Fibers, primarily composed of polyethylene terephthalate, polypropylene, and polyester, were the most common plastic types identified via FTIR spectroscopy. The study also detected trace metals like aluminum and zinc on these microplastics, raising concerns over their role as pollutant carriers. Using the Pollution Load Index, the region was categorized as having a moderate level of pollution. The study linked pollution to waste management gaps, while also stating that wind and rain serve as major transport mechanisms. These findings stress the need for improved conservation and waste strategies, even in seemingly remote or protected areas.

Discussion of general aspects

Gallitelli and Liro examine river garbage patches (RGPs):dense, localized accumulations of plastic in rivers that are distinct from the more diffuse ocean garbage patches (OGPs). While RGPs cover smaller areas, their plastic concentrations can be orders of magnitude higher than OGPs. As rivers serve both as transport routes and sinks for plastic waste, understanding RGP dynamics is vital for effective clean-up and pollution control. The authors argue that RGPs, due to their accessibility and relative stability, present valuable opportunities for targeted mitigation. They advocate for more research into plastic abundance and distribution in rivers, and suggest that citizen science could play a significant role in monitoring and cleanup. The study emphasizes a shift in focus from oceans to rivers, which often retain plastic until flood events mobilize it downstream. A better understanding of RGPs could bridge existing knowledge gaps and lead to more efficient plastic pollution management strategies.

Outlook and future challenges

Based on the recent advances in river plastic research we identified three main avenues for future work. First, there is still a strong need for the harmonization of plastic monitoring methods to facilitate comparability across environmental compartments, plastic size ranges, and locations around the world. Harmonization efforts should focus on both developing guidelines and standards for data Research Topic (e.g., Wendt-Potthoff et al., 2020; Isobe, 2024), and developing databases for standardized data storage, processing and reporting.

Second, a deeper understanding of plastic entry, transport, and retention processes is still required. This challenge can be partly solved through increased availability of comparable data. In tandem, new conceptual and physical models may support improving our understanding of the role of hydrology, climate change, and anthropogenic factors on the current and future global plastic pollution budget. The origin and fate of plastic items and particles must be better understood to identify relevant sources, sinks, and impact on land, in rivers, and in the ocean.

Finally, a special focus should be placed on the development of assessment tools to quantify the potential and actual efficacy of intervention measures. With global, regional and local initiatives to reduce plastic pollution in the environment, it is crucial to provide quantitative support for the selection, implementation and evaluation of interventions, ranging from prevention strategies to removal technologies. To effectively mitigate plastic pollution in the environment, a combination of improved monitoring, scientific knowledge acquisition, global data comparison, and intervention assessment are paramount.

Author contributions

ML: Writing – review and editing, Writing – original draft. DG-F: Writing – original draft, Writing – review and editing. FM: Writing – original draft, Writing – review and editing. LB: Writing – review and editing, Writing – original draft. TvE: Writing – review and editing, Writing – original draft.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. DG-F was funded by the European Union under the Horizon Europe (HORIZON-MISS-2022-OCEAN-01) project “INSPIRE - Innovative Solutions for Plastic Free European Rivers” (grant agreement No. 101112879), part of the EU Mission “Restore our Ocean and Waters” and endorsed under the UN Ocean Decade. ML was funded by the Austrian Academy of Sciences and the Austrian Federal Ministry of Education, Science and Research as part of the initiative “Earth System Sciences Research Programme” Project “AlPlast”.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

Publisher’s note

References

Ahmed, D., Sapkota, R., Churuvija, M., and Karkee, M. (2023). *Machine vision-based crop-load estimation using yolov8*. arXiv:2304.13282.

European Commission (2022). Single-use plastics. Available online at: https://environment.ec.europa.eu/topics/plastics/single-use-plastics_en (Accessed April, 2025).

Fan, Y., Mao, S., Li, M., Wu, Z., and Kang, J. (2024). CM-YOLOv8: lightweight YOLO for coal mine fully mechanized mining face. *Sensors* 24 (6), 1866. doi:10.3390/s24061866

IISD (2022). Unea launches negotiation of plastic pollution treaty, science body on chemicals. Available online at: https://sdg.iisd.org/news/unea-launchesnegotiation-of-plastic-pollution-treaty-science-body-on-chemicals (Accessed April, 2025).

Isobe, A. (2024). *The guidelines for harmonizing marine litter monitoring methods using remote sensing technologies ver.1.0*. Tokyo, Japan: Ministry of the Environment Japan, 89. (including Annex and Appendix).

Issac, M. N., and Kandasubramanian, B. (2021). Effect of microplastics in water and aquatic systems. *Environ. Sci. Pollut. Res.* 28, 19544–19562. doi:10.1007/s11356-021-13184-2

Liro, M., Mikuś, P., and Wyżga, B. (2022). First insight into the macroplastic storage in a mountain river: the role of in-river vegetation cover, wood jams and channel morphology. *Sci. Total Environ.* 838, 156354. doi:10.1016/j.scitotenv.2022.156354

March, A., Tsouza, A., Nieminen, L., Winton, S., Arora, H., Shejuti, S.-M., et al. (2024). National action plans: effectiveness and requirements for the global plastics treaty. *Camb. Prisms Plast.* 2, e11. doi:10.1017/plc.2024.11

Range, D., Scherer, C., Stock, F., Ternes, T., and Hoffmann, T. (2023). Hydrogeomorphic perspectives on microplastic distribution in freshwater river systems: a critical review. *Water Res.* 245 (1), 120567. doi:10.1016/j.watres.2023.120567

Tasseron, P., van Emmerik, T., Vriend, P., Hauk, R., Alberti, F., Mellink, Y., et al. (2024). Defining plastic pollution hotspots. *Sci. Total Environ.* 934, 173294. doi:10.1016/j.scitotenv.2024.173294

UNEP (2024). Zero draft text of the international legally binding instrument on plastic pollution, including in the marine environment. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/43239/ZERODRAFT.pdf.

Van Emmerik, T., Mellink, Y., Hauk, R., Waldschläger, K., and Schreyers, L. (2022). Rivers as plastic reservoirs. *Front. Water* 3, 786936. doi:10.3389/frwa.2021.786936

van Emmerik, T. H. M., Schreyers, L. J., Mellink, Y. A. M., Sok, T., and Arias, M. E. (2023). Large variation in Mekong river plastic transport between wet and dry season. *Front. Environ. Sci.* 11, 1173946. doi:10.3389/fenvs.2023.1173946

Vriend, P., Roebroek, C. T., and van Emmerik, T. (2020). Same but different: a framework to design and compare riverbank plastic monitoring strategies. *Front. Water* 2, 563791. doi:10.3389/frwa.2020.563791

Wendt-Potthoff, K., Avellán, T., van Emmerik, T., Hamester, M., Kirschke, S., Kitover, D., et al. (2020). Monitoring plastics in rivers and lakes: guidelines for the harmonization of methodologies. *U. N. Environ. Programme*.